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FINAL REPORT
The ARTS-DTAG Project
Technical step from DTAGv2 to DTAGv3

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SUMMARY

Several modifications were introduced to the ARTS system in order to make it a reliable delivery system for digital recording tags (DTAGs), described in the final technical report of the ARTS-DTAG project (N00014-10-1-0380). With the new version 3 design of the DTAG, the DTAGv3, the setup with the ARTS and the ARTS-carrier robot required important modifications. The new tag is smaller, lighter and with a new form factor for the housing. We have made a new design of the ARTS-carrier, and tested the new shock absorbing docking grip for the DTAGv3 with positive results. This shock absorber technique reduce the sliding and rebounding of the tag upon impact with the target, reduces the impact forces upon the tag and its electronic components, and soften the impact forces on a target animal. This new setup enables the v3 DTAG to be launched at longer range and at a lower launching pressure from a platform close to sea level.

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ADJUSTING THE ARTS TO THE NEW GENERATION DTAG

A technical step from DTAGv2 to DTAGv3

The DTAG was originally developed to record an animal's responses to acoustic stimuli, such as naval sonar signals, and the traditional method for deploying these non-invasive (suction cup) tags on large and mid-sized cetaceans has been to use long carbon fiber poles (Moore *et al.* 2001, Johnson and Tyack 2003). This technique works well with some of the large whales, but some mid-sized cetaceans (e.g., beaked whales, killer whales and minke whales) tend to be quicker, more maneuverable, and elusive, making pole tagging rather inefficient (Kvadsheim *et al.* 2009). In order to extend the tagging range and thus increase tag deployment rate, a system launching the DTAG through the air using a pneumatic launcher (Aerial Rocket Tag System, or ARTS) was developed forming the ARTS-DTAG system. A preliminary version of this system had already proven to have potential in improving tagging efficiency, particularly with "difficult" whale species (Kvadsheim *et al.* 2009).

An extensive test program, including ballistic testing in the lab, at sea testing on a floating dummy whale and a field trial with tag deployments on minke and pilot whales, finalized the former project with the ARTS-DTAGv2.

The new version of DTAG, the DTAGv3, is radically changed in terms of size, weight and robot-grip, compared to the former DTAGv2 (fig.1/left). Despite these major changes, we were able to reuse some of the solutions from the ARTS-DTAGv2-system to able a stable ARTS launching of the DTAGv3. All major flight factors and details on reduction of impact forces were included in the new ARTSCarrier robot for the DTAGv3. A new Grip-docking system was constructed for the DTAGv3 (fig.1/right).

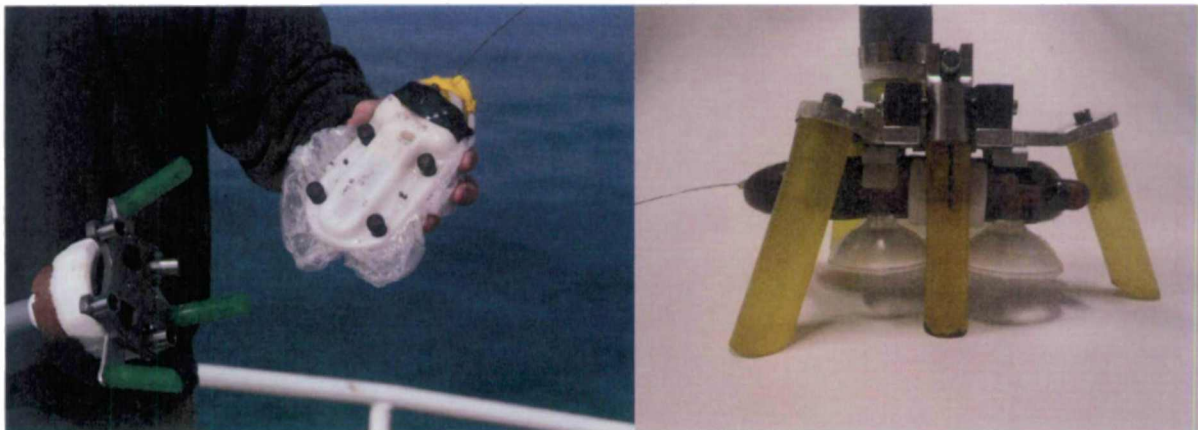


Figure 1: The ARTSC10 and a dummy DTAGv2 (left); new ARTSCarrier robot (ARTSC12) with a grip-docking system for DTAGv3 (right)

To optimize performance of the ARTS-DTAGv3 system, we have modified certain details and components; the technique of absorbing the impact forces in front of the tag is extended. Our shock absorbing system ("giraffe leg-technique") consists now of five studs made of flexible material mounted on the ARTS-carrier robot. Three of these are placed around the DTAGv3, and 2 support the grip-docking system for the DTAGv3 during flight (Fig.1/right, Fig.2/left). The final version of the ARTS-carrier and robot is made of polyurethane (shore-90) where three of the shock absorbing studs are 20mm in diameter and 80mm long, while the grip-docking studs are shorter and 18mm in diameter. Half of the surface at the end of the studs is angled 135 degrees compared to the orientation of the suction cups, and all studs are angled about 120 degrees compared to this same orientation. With this configuration, once the tag is launched, the shock absorbing studs will open

up on the target and flex, and absorb a major part of the impact energy (Fig.2/right). The distance from the stud end to the bottom of the suction cups is 25 mm.



Figure 2: the new ARTSC12 with five GL studs shown with empty docking station (left); and when docking the DTAGv3 (right)

Details of the robot of the ARTS-carrier are shown in figure 3, with its flexible adjustments of the docking station (left) and the flexible junction from the ARTS-carrier to the robot (right).

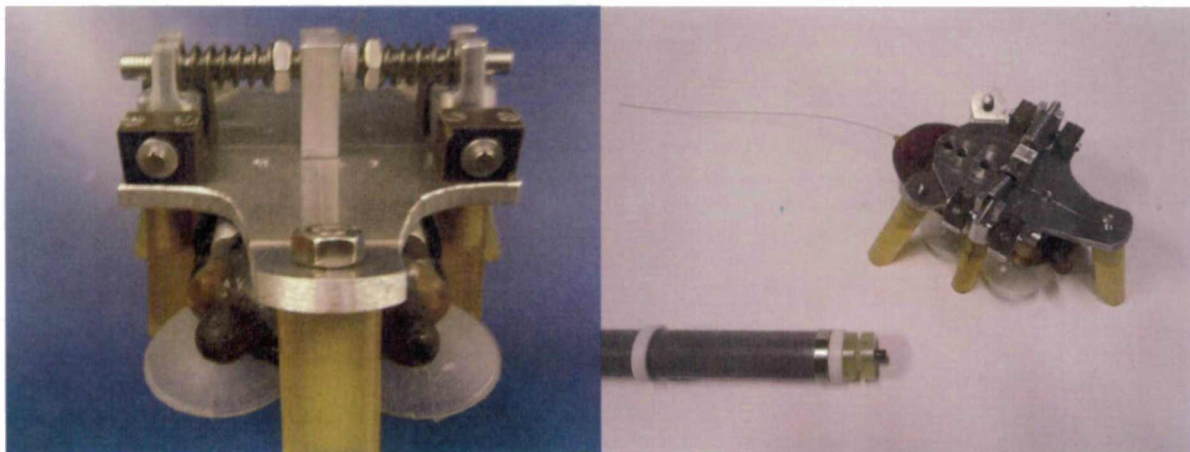


Figure 3: detail of robot grip docking station of the ARTSC12 (left); and details of the ARTSC12 with the flex junction between the ARTS carrier and the robot (right)

The ARTS barrel is cut to 600mm, furthermore the balancing weight of the ARTS-carrier, holding a floating material of ethaphom 220, have been tested to assure good aerodynamics and reliable flight stability.

A new sight arrangement was constructed in the former project ARTS-DTAGv2, however, the control of rapid change in launching pressure and a more precise launching pressure control still needs improvement.

WORK COMPLETED

During the testing period the same dummy whale targets were used as in the ARTS-DTAGv2 project. The final laboratory version was a hard packed plastic structure of 50x70 cm wrapped in a 12 mm rubber coat, with a target area of 0.35 m². The target design provided the capability of

adjusting the angle at which the tag struck the target. Extensive testing of the ARTS-carrier was performed during the winter of 2009/2010, including a total of 308 launching tests on a dummy whale in the test laboratory, and a total of 47 tests on a dummy whale at sea. The initial tests in the laboratory were performed at a distance from the target of 10 m, and used different pressure ratings for the launcher (8, 10, 12 bar).

We began this project by testing various robot holders for the DTAGv3, before ending up with the final version seen in figure 2 & 3. We videotaped all of the launchings to help our analysis of the tag trajectory and study the impact forces and attachment of suction cups to the target. At the end of the test period all launchings were documented by using a fast-speed video camera (Photron, Fastcam, APX, RS). The new five-stud configuration combined with the new grip docking robot proved immediately to be very effective in absorbing shock and reducing sliding. The docking construction is flexible and adjustable to fit the body of the DTAGv3.

The dummy whale was always kept wet and initially angled at 90 degrees to the tagger. The new sight system resulted in significantly improved accuracy of the system during lab-testing, with close to a 100% hit rate. Testing with chamber pressure on the ARTS from 6 to 10 bars gave us a variable curved trajectory, but with sight practice we obtained successful hits within this pressure range. The lighter version DTAGv3 has a less curved trajectory, and for target distances up to 12 meters, 10 bar is too high with higher risk of rebounding on the target. We restricted the launching pressure to 8 bar for a 10 m and 12m target distance. The next step was to change the angle of the target to create a more realistic scenario, closer to a field operation. The dummy whale was angled to 60-70 degrees, and the launching values and distance were kept at the same levels of 8 bar and 10 meters. With this configuration the ARTS-carrier system holding the DTAGv3 still deployed the tag on the target although we experienced some rebounds, more often the DTAGv3 slid a little on the dummy whale and stuck. A total of 169 controlled lab launchings were performed during the test period from August 2011 to February 2012 at the facilities of FFI, Horten, Norway. During this period, we registered no damage to the DTAGv3 dummy tag or to the new ARTS-carrier.

No field testing was scheduled for this project. Despite this several attempts were made to test the system in the field, mostly during 3S-trials. Since this effort was always secondary to other trial objectives, we never had a chance to actually test the ARTS launching of DTAGv3 in the field.

APPLICATIONS AND FUTURE WORK

During the 3S-2012 trial, using the ARTS-carrier, the hit and miss ratio of 50/50 vs. close to 100% hits during lab testing indicate that the ARTS-DTAG system still needs improvement to increase resiliency. We think the main problem when working at sea with moving targets is the shooter's ability to make quick decisions about range to target and thereby choose the appropriate launching pressure and aimpoint. Further steps will be taken to improve the pressure control.

However, with a lighter setup using the new ARTS-carrier with DTAGv3, the system will be more accurate with a less curved trajectory from launcher to target, and thus more reliable.

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